

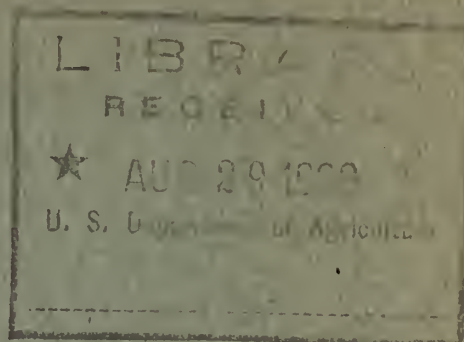
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UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Region Eight
Albuquerque, New Mexico

Hugh G. Calkins
Regional Conservator



NOTES ON THE UPPER SANTA CRUZ WATERSHED-ARIZONA

Regional Bulletin No. 49
Conservation Economics Series No. 22
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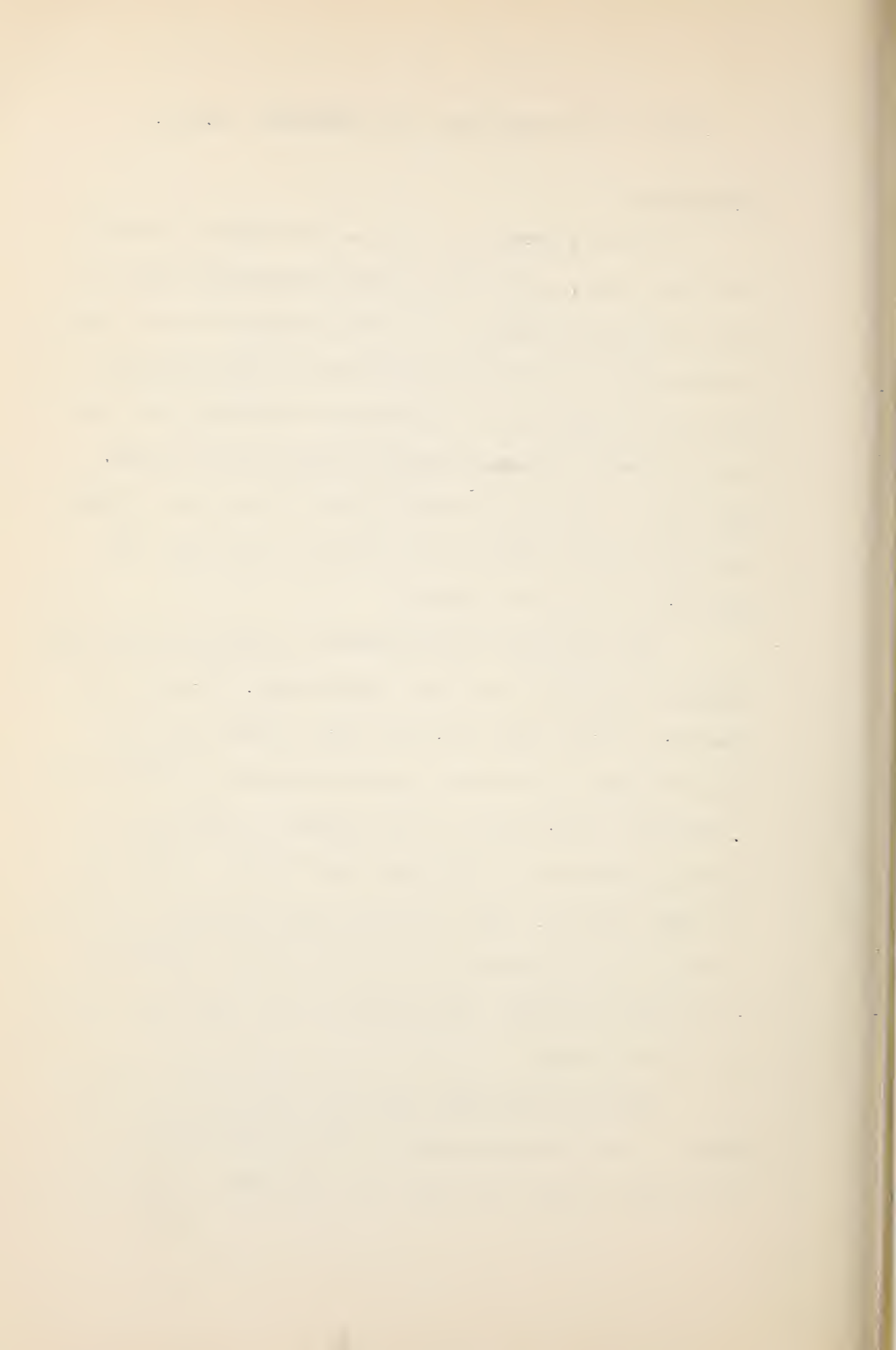
NOTES ON THE UPPER SANTA CRUZ WATERSHED - ARIZONA

Introduction

The Santa Cruz River rises on the southwest slope of the Canelo Hills, a low range in the southeastern corner of Santa Cruz County, Arizona. It flows southward for 26 miles. Fourteen miles below the Mexican border it curves westward around the southern end of the Patagonia Mountains, and then flows northward, entering Arizona 6 miles east of Nogales. From there it flows in a northwesterly direction past Tucson, and joins the Gila River in the vicinity of Maricopa, 160 miles from the Mexican boundary.

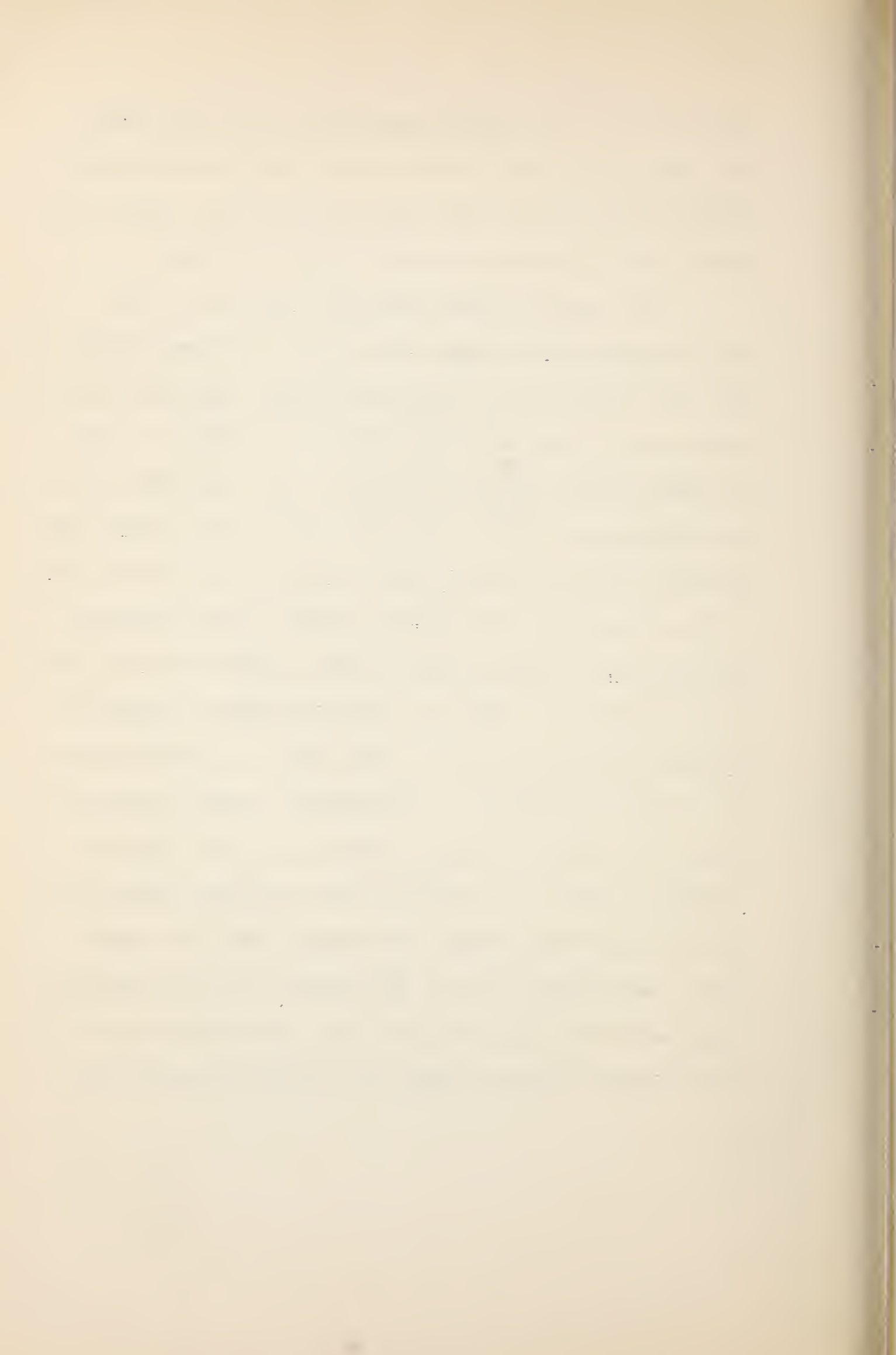
The total area of the watershed in Pima and Santa Cruz counties is approximately 3,900 square miles. Approximately one-third of this upper watershed area is above 3,500 feet elevation, and at one place reaches an elevation of more than 9,000 feet. The rainfall on this portion of the watershed which is practically all in Santa Cruz County, is more than 16 inches annually. The rest of the upper watershed is between 2,000 and 3,500 feet elevation, and the annual rainfall is rarely over 11 inches. This portion of the upper watershed is all in Pima county.

From its headwaters into Mexico and for some 20 miles after it enters Arizona again, the Santa Cruz is usually a surface stream. From a few miles below Calabazas, where the valley



widens, it is sunken stream during most of the year, except for a few places where it flows on the surface for short distances. Only at heavy flood times does the river flow at the surface all the distance to where it joins the Gila.

This report will deal only with that part of the Santa Cruz Watershed located in Santa Cruz and Pima counties. This area includes all of the high altitude, high precipitation portion and a large percentage of the low altitude, low precipitation portion of the watershed as well. The high altitude area produces most of the water that flows in the streams, and therefore, from the point of view of stream flow control work, is far and away the most important portion of the watershed, and the locally proposed flood control measures call for structures in this area. There the Santa Cruz River is joined by numerous tributaries, most of which enter it at right angles. All of these tributaries are intermittent streams, being dry washes for a varying number of months each year. The most important of the upper tributaries are the Nogales Wash (also known as the Potrero Creek), the Soneita Creek, the Sopori Creek, and Josephine Canyon. The Soneita Creek and Josephine Canyon enter the Santa Cruz from the north and east, and the Sopori Creek and Nogales Wash enter the Santa Cruz from the



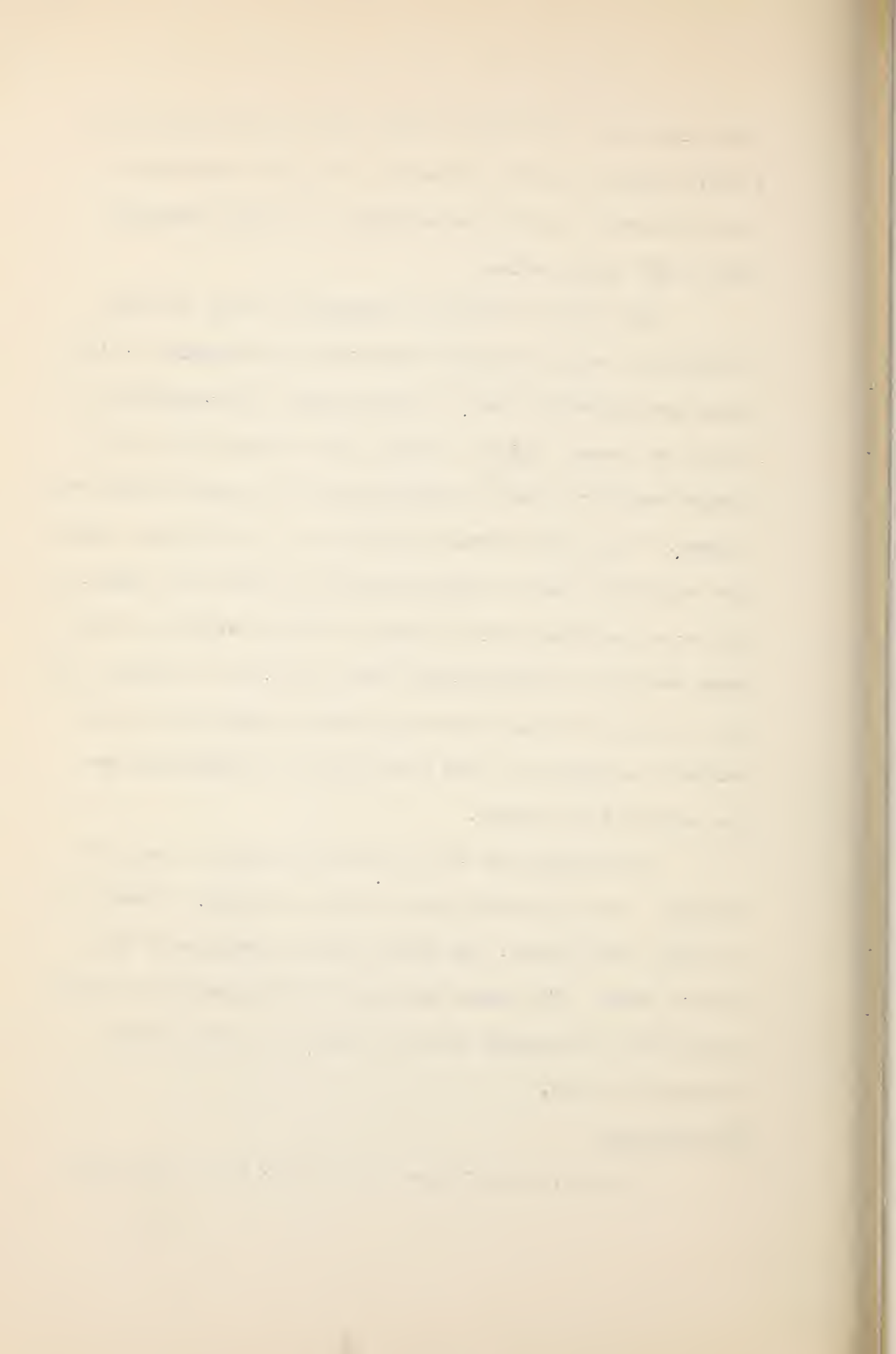
south and west. The Rillito Creek, entering the Santa Cruz a short distance north of Tucson, is the most important of the tributaries entering below Tucson. It has a drainage area of 947 square miles.

The kind and amount of vegetative cover, as might be expected, varies markedly from the low precipitation to the higher precipitation areas. In the former the vegetation is typical of desert regions - cacti, small mesquite and other drought resisting plants, widely spaced on account of the arid climate. The higher elevation area has a comparatively luxuriant vegetative cover of many varieties of trees and brush, as well as an excellent cover of grass, most of which is of the grama varieties, predominantly black grama, and sacaton. This area is one of the best yearlong grazing areas in the entire southwest according to some Forest Service technicians who have examined the ranges.

Practically all of the upper watershed is used for grazing. The only arable land is found along the channel of the Santa Cruz itself, and along certain stretches of the Sonoita Creek. The extent and use of both grazing and arable lands will be discussed under the section of this report dealing with land.

Brief History

The Santa Cruz Valley was the first area in Arizona



settled by non-Indians. In 1691 a Jesuit, Eusebio Kino, reached the Indian rancherias of Guevavi and Bac. The Jesuits conducted a mission at Bac from 1701 to 1767, and the Santa Cruz Valley became an important route from western Mexico to Arizona and California. A Spanish settlement was established near present-day Tucson in 1763. The chief dependence of the few non-Indians for livelihood during the early days appears to have been a limited amount of flash flood irrigation agriculture, learned from the Papago Indians, and, somewhat later, the raising of wild longhorn cattle and mining. The latter industry increased with the coming of American immigrants after 1840. The peaceful Papagos from time immemorial and the Spanish and Mexican settlers from the time they arrived, had suffered continual depredations at the hands of the hostile Apache Indians. Late in the eighteenth century an adobe wall was built around the presidio at Tucson, and the little walled city remained, after the Mexican War, the metropolis of the southwestern frontier of the United States for many years. A small garrison of American troops protected the settlement against the Apaches after 1850, but this garrison was removed at the outbreak of the Civil War. Tucson had a hectic Civil War history, falling into the hands of Confederate troops at one time. In 1865 another garrison was sent out from the east

and these troops finally conquered the Apaches. From 1861 to 1878 there was little development in the Santa Cruz area, although some Americans moved in after the Gadsden Purchase. In 1878 some rich ores were discovered at Tombstone, near Tucson, and the mining industry had a great revival. The Southern Pacific railroad arrived in Tucson in 1880, and the region has had a continuous development since.

Population

The state of Arizona has had a tremendous increase in population since 1870, as the following table from the U. S. Census shows.

YEAR	POPULATION	% INCREASE
1870	9658	
1880	40440	318.7
1890	88243	118.2
1900	122931	39.3
1910	204354	66.2
1920	334162	63.5
1930	435573	30.3

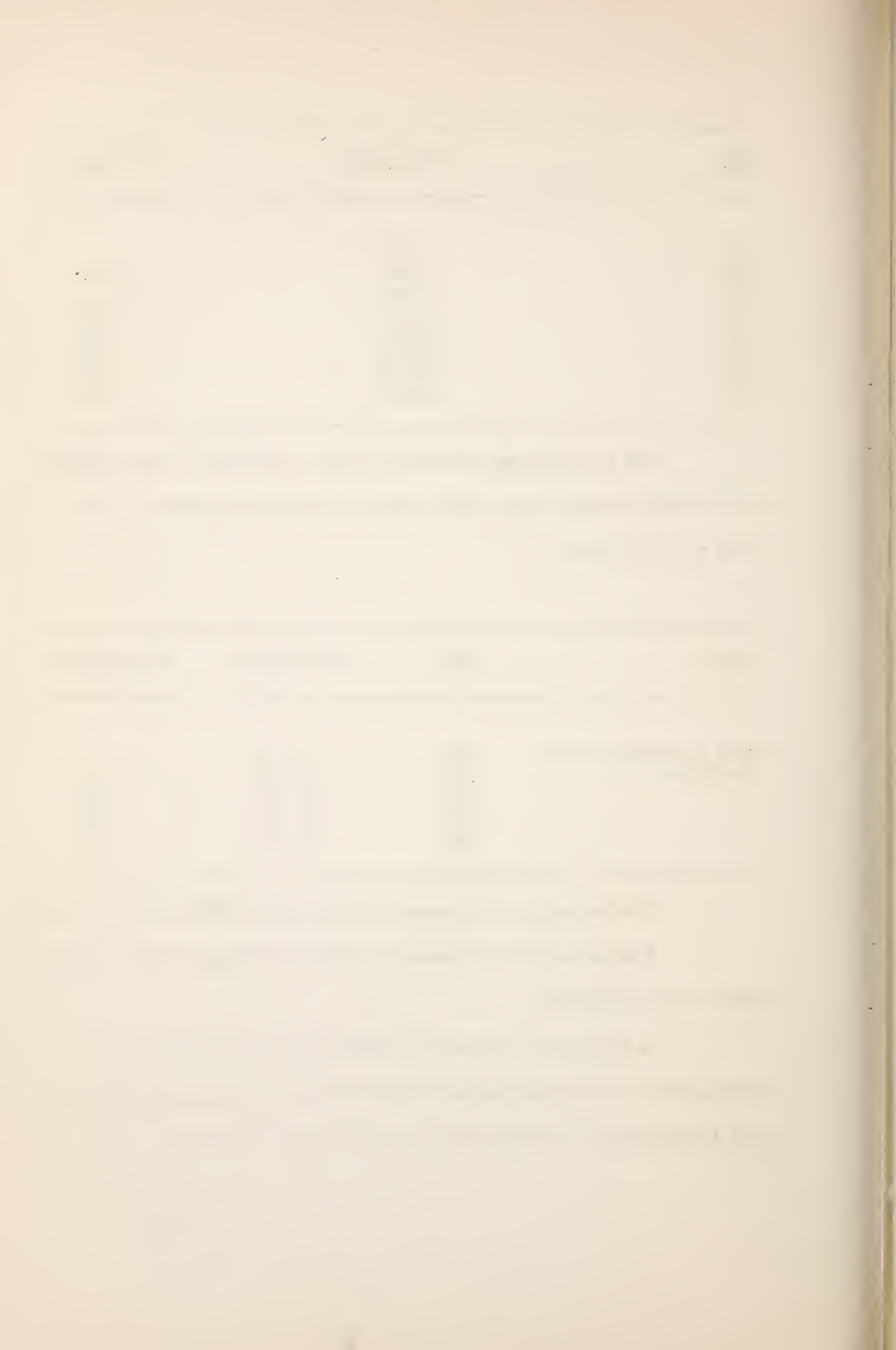
The population increase of Pima and Santa Cruz counties since 1890 has kept pace with the population increase of the rest of the state.

COUNTY	YEAR	POPULATION	% INCREASE
Pima and Santa Cruz Counties	1890	12,673	
	1900	19,234	51.7
	1910	29,584	53.8
	1920	47,369	60.1
	1930	65,360	38.0

Percentage of increase in the state 1890-1930 is 393.6%.

Percentage of increase in Santa Cruz and Pima Counties 1890-1930 is 415.6%.

A large and increasing percentage of the growth in population in Pima and Santa Cruz counties is accounted for by the increase in the population of the city of Tucson.



YEAR	POPULATION OF TUCSON	NUMERICAL INCREASE	:	NUMERICAL INCREASE SANTA CRUZ AND PIMA COUNTIES	% OF TOTAL INCREASE ACCOUNTED FOR BY TUCSON
1890	5150		:		
1900	7531	2381	:	6561	36.3
1910	13193	5662	:	10350	54.7
1920	20292	7099	:	17785	39.9
1930	32506	12214	:	17991	67.8
			:		
	TOTAL	27356	:	52687	51.9

The above tabulation of U. S. Census data indicates the dominant position of the city of Tucson in the two counties in which is located the upper Santa Cruz watershed in Arizona. Actually, the population of the two counties is largely concentrated in the Santa Cruz Watershed. Although the two counties together comprise an area of 10,734 square miles, and the Santa Cruz watershed is only approximately 30 to 35 per cent of this area, still within the Santa Cruz watershed (not including Quijotoa) live 58,565 persons or 89% of the total population of the two counties. The Indian population in the two counties totals 5,346, and of this number some 600 live in the Santa Cruz watershed.

To summarize the above information, the population within the upper Santa Cruz watershed in Arizona is 89% of the population of Pima and Santa Cruz counties, although the area

of the watershed is only 30 to 35% of the total area of the two counties. The population within the watershed shows a tremendous concentration at Tucson, with a minor concentration at Nogales, these two population centers together in 1930 having a population of 38,640 or 65.9% of the total population within the watershed.

The rest of the population, in 1930 numbering 19,925, is located throughout the watershed usually in villages and farms along the stream courses. The important villages by precincts, their population and the streams on which they are located are as follows:

NAME OF COMMUNITY (Precinct)	POPULATION 1930	COUNTY
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SANTA CRUZ RIVER: (From its headwaters down to Pinal County)

Canille	65	Santa Cruz
San Rafael	65	"
Lochiel	154	"
Santa Cruz	398	"
Calabasas	324	"
Tubac	515	"
Continental	171	Pima
Sahuarita	271	"
San Xavier	908	"
Tucson precincts outside the city limits	8360	"
Cortaro	415	"
Marana	774	"
Sub-total	13,020	

SONOITA CREEK:

Sonoita	88	Santa Cruz
Patagonia	710	"
Harshaw	259	
Sub-total	1,057	

SOPOTI CREEK:

Montana Camp	729	Santa Cruz
Sopori	172	"
Arivaca	539	Pima
Sub-total	1,440	

RILLITO CREEK:

Fort Lowell	1283	Pima
Condron Pastime	1272	"
Tanque Verde	529	
Sub-total	3,084	

MISCELLANEOUS DRY WASHES (mostly mining communities)

Twin Buttes	372	Pima
Greaterville Cottonwood	236	"
Vail Helvetia	40	"
Pantano	430	"
Silverbell	246	"
Sub-total	1,324	

Total 19,925

Only Canille, San Rafael and Lochiel of the above listed communities are located on the Santa Cruz above where it enters Mexico. There are two or three villages in Mexico, whose population or dependency upon the lands of the watershed was not ascertained. Apparently, they are merely mining villages belonging to the huge Green-Cananea Corporation, which owns the major portion of the watershed in Mexico. The first settlement after the river re-enters Arizona is Santa Cruz, a scattered farm and ranch community, and then the river enters the Baca Float, an American land grant, in which is located Calabasas, a farming community. From the Baca Float north there is more or less continuous settlement to Tucson. Of the 19,925 people scattered throughout the watershed, approximately 4,000 live in mining camps.

Land

The drainage area of the Santa Cruz above Tucson is given as 2,100 square miles, and the drainage area of the Rillito Creek is given as 947 square miles. This comprises the most important portion of the Santa Cruz watershed in Pima and Santa Cruz counties insofar as human dependency is concerned.

The total land area of Santa Cruz county is 1229 square miles, and approximately 1,100 square miles of this is in the

Santa Cruz watershed. The ownership status of the 1,100 square miles in the watershed is as follows:

Coronado National Forest	750 sq. miles	68.3%
Public Domain	5 " "	.4%
Private Lands	<u>345</u> " "	<u>31.3%</u>
	1100 sq. miles (1)	100%

The total land area of Pima County is 9,505 square miles, and the approximate ownership status of the land is as follows:

Indian Reservation	3515 sq. miles	38.8%
Public Domain and School lands	3725 " "	39.
National Forests	602 " "	6.
National Parks & Monuments	99 " "	1.
Military Reservation	4 " "	-
Private Lands	<u>1560</u> " "	<u>16.</u>
Total Area	9595 sq. miles (1)	100%

The Pima County drainage areas of the Santa Cruz above Tucson, and of the Rillito Creek are approximately 1000 square miles each. The 1000 square miles in the Santa Cruz watershed in Pima County above Tucson is divided as follows:

Coronado National Forest	163 sq. miles	16.3%
Santa Rita Range Reservation	64 " "	6.4
Portion of Papago Indian Reservation	110 " "	11.0
Public Domain (approximately 39% of the area)	390 " "	39.0
Private Lands	<u>273</u> " "	<u>27.3</u>
	1000 sq. miles (2)	100%

(1) The land status for the entire counties secured from the Tucson and the Nogales Chambers of Commerce, and checked with Forest Service maps and the Pima County Agent.

(2) See Footnote 1 page 12.



The watershed of the Rillito Creek is divided as follows:

Nat'l Forests and Nat'l Monuments	430	sq. miles	45.3%
Military Reservation	4	" "	.4
Public Domain	369	" "	39.0
(Approx. 39% of remaining land)			
Private lands (approximately)	144	" "	15.3
	<u>947</u>	" "	<u>100%</u>

The recapitulation of the above information for both
Pima and Santa Cruz Counties:

Total drainage area of the Rillito and the Santa Cruz
above Tucson: 3047 square miles.

The status of this land is as follows:

Nat'l Forests and Nat'l Monuments	1343	sq. miles	44%
Public Domain	764	" "	25.0
Indian Reservation	110	" "	3.6
Military Reservations	4	" "	.2
Range Reservations	64	" "	2.2
Private lands	762	" "	25.0
	<u>3047</u>	" "	<u>100%</u>

The Use of Private Lands

The area of the private lands in the drainages of the Santa Cruz and Rillito aggregate approximately 762 square miles, or 487,680 acres. In 1936 the total acreage under cultivation in the two counties, practically all of which is in the Santa Cruz watershed, was between 23,000 and 24,000 acres. Approximately 7,000 acres of this was below the confluence of the Rillito

(1) The land status of the drainage areas was determined by examination of large scale Forest Service maps except in the case of the public domain area, which was determined by finding the ratio of public domain to other lands in the entire county and assuming the same ratio holds in the drainage area.

and the Santa Cruz. The cultivated acreage on the Rillito and the Santa Cruz above Tucson, then, was approximately 17,000 acres, or in the neighborhood of 3.4% of the acreage under private ownership in the same area, and 71% of the total cultivated acreage in the two counties. Of this acreage 3,000 acres are in the Rillito drainage, and approximately 14,000 acres are in the Santa Cruz above Tucson. The latter acreage is divided into 9,000 acres in Pima County and 5,000 acres in Santa Cruz County. In the two counties together there are approximately 1,000 farmers, 750 in Pima County and 250 in Santa Cruz County. The following table, prepared by the Pima County Agricultural Extension Agent, and presented at the Flood Control Hearing held in Nogales September 21, 1937, gives an indication of the cropping and production of Pima County farms. Practically all of the irrigation water in Pima County is pumped up from the water bearing bed of the Santa Cruz River. The average lift is 60 feet.



CROP	ACREAGE	YIELD	TOTAL PRODUCTION	PRICE	TOTAL VALUE
Short Staple Cotton	3747	600 lbs. per A.	Lint 2,270,500# Seed 1,851 tons	.12 $\frac{1}{2}$ \$31.00 per T.	\$278,236 57,381
Long Staple Cotton	1367	271 lbs per A.	Lint 370 928 Seed 433 Tons	.23 $\frac{1}{2}$ \$31 00 per T.	87,168 13,423
TOTAL	5114				\$436,208
Grain & Forage Sorghums	2000	10 Tons of Ensilage per Acre	20,000 Tons	\$6.00 per T.	120 000
Corn	1350	6 Tons Ensilage per acre	8,100 Tons	6.00 per T.	48,600
Truck Crops	200			200.00 per A.	40,000
Alfalfa	1250	4 Tons per Acre	5,000 Tons	12.00 per T	60 000
Small Grains	600	30 bushels	18,000 Bushels	.75 per Bu.	13,500
Potatoes	60	50 Sacks per Acre	3,000 Sacks	2.50 per sk.	7,500
Hay Crops, Johnson Grass & Forage Sorghums	2500	1 $\frac{1}{2}$ Tons	3,750 Tons	8.00 per T.	30,000
TOTAL	13074*				755 808

* This acreage is not the total acreage in cultivation in Pima County which the County Agent

estimates at 19,000 acres in 1937.

The Pima County Agent in his 1935 report listed the total agricultural income of the approximately 750 farmers in that county in 1934 as follows:

Cattle	\$570,000	31%
Cotton	414,500	22
Poultry	394,000	21
Dairy	300,000	16
Field Crops	82,000	6
Truck	56,000	3
Miscellaneous	15,000	1
	<u>1,832,000</u>	<u>100%</u>

These percentages for the different sources of agricultural income probably hold within the Pima County drainage area of the Santa Cruz.

The financial condition of the two most important irrigation districts is described as follows in Volume II, page 26, of the Arizona State Planning Board Report for 1936. These two districts are included in the list of "problem areas":

"Flowing Wells Irrigation District 2,568 acres--2,000 acres of excellent, fertile land, balance waste and alkali--ample water for 2,000-acre project (1,800 acres, net)-- exceptionally fine market for truck crops and dairy products close by at Tucson-- heavy bonded indebtedness and tax delinquency-- some farm desertions due to discouragement over debt--people willing to reduce area to 2,000 acres, and have applied to R.F.C. for refinancing -- bondholders have offered to take 25 cents on the dollar, if in cash (not more bonds).

Jaynes Irrigation

975 acres, originally cut into small tracts--many deserted places--good soil, but water deficient and somewhat costly (all from wells)-- excellent market-- heavy indebtedness and tax delinquency--deadlock and open hostility between bondholders and the few remaining landowners who are farming."

The bonds of the Flowing Wells District have been in default since July, 1931; and those of the Jaynes District since January, 1928.

The agriculture of Santa Cruz County differs considerably from that of Pima County, and most of the difference is accounted for by the fact that very little cotton is grown in the former. The percentage of the total cultivated land area in the various crops in the two counties in 1929 is given by the U. S. Census as follows:

<u>Crop</u>	<u>% In Pima County</u>	<u>% in Santa Cruz County</u>
Corn	9.2%	42.8%
Hay	31.2	48.4
Cotton	53.6	6.3
Vegetables	4.1	1.3
Miscellaneous Crops	1.9	1.2
	<u>100%</u>	<u>100%</u>

From a brief investigation it appears that the percentages given to the various crops in the above tabulation for Santa Cruz County is probably correct for 1937 as a very high percentage of each farm is given over to the production of supplementary feed for cattle. The table shows that 91.2% of the cultivated land in Santa Cruz County is given to hay and corn. The agriculture of Santa Cruz County differs further from that of Pima County in that the acreages farmed per farm are larger as a rule. A list of land users in the upper

Santa Cruz Valley compiled by an SCS representative with the aid of the former Santa Cruz County Agent shows that the acreages farmed range from 40 acres to 1400, and that most of them are over 100 acres.

The private grazing lands within the watershed in the two counties, amounting to approximately 660,000 acres, are all used as grazing lands for cattle and horses, as there are practically no sheep in the area. The carrying capacity of the range lands increases greatly from the lower to the higher reaches of the watershed. Consequently, whereas cattle raising is a secondary activity in Pima County, albeit an important one as it contributed approximately 31% of all agricultural income, in Santa Cruz County it is by far the chief industry, and practically all agricultural activity is tied to cattle raising. Besides the 250 farmers listed above there are 45 large cattle ranchers (i.e. having breeding herds of over 100 cattle each) in Santa Cruz County. These ranchers carry on a varying amount of farming on their lands, but for the most part they furnish the market for the surplus feed produced on the other farms. These ranchers depend upon public lands to a varying degree, and a discussion of the use of public lands is necessary in a presentation of the economy of the upper SantaCruz drainage. The private landholdings of

the large ranchers in the Arizona portion of the drainage range from the 97,000 acres of the Adams-Pendleton outfit owning the Baca Float, the 46,000 acres of the Green-Cananea Company, which includes the San Rafael Spanish Land Grant, the 10,000 acres belonging to T. F. Griffin which includes the Buena Vista Grant, down to 160 acres or so owned by 24 of the ranchers who depend almost entirely upon National Forest lands for grazing. Approximately 75 farmers, owning 1 to 10 head of stock each, do not get grazing permits. (According to one of the local rangers, they can care for their cattle on their private lands.)

The Use of Public Lands

All of the public lands in that portion of the drainage area of the Santa Cruz River in Santa Cruz County are under the administration of the U. S. Forest Service as a part of the Coronado National Forest. These lands are practically all included in two administrative districts-- the Tumacacori and the Patagonia districts. All the large ranchers except the Adams-Pendleton and the Green-Cananea outfits, the two largest landowners, are dependent to a varying degree upon National Forest grazing. Besides the 43 large stock owners in the National Forest there are 25 permittees with less than 100 head each. Altogether 14512 cattle units are grazed yearlong

in these two districts of the Coronado National Forest. This is approximately 32% of the total number of cattle units in the area, although the percentage of the total land area in National Forest is 68%. This is probably accounted for by the higher productivity of the private lands, especially in the case of cultivated lands, as well as by overgrazing on those lands. There is now a cow unit per 33 acres in the National Forest lands in the area.

Livestock in Santa Cruz County

The best available data, those of the U. S. Forest Rangers in the two districts involved, give the following information regarding the total stock count for the Santa Cruz Watershed in Santa Cruz County.

	<u>Cattle</u>	<u>Horses</u>
Total Numbers of Stock Belonging to National Forest Users:	39,359	849
Total Number Grazed in Arizona by the Green-Cananea Corp:	2,500	80
Total Number Owned by the Adams- Pendleton Outfit:	2,500	70
Total Number Owned by 75 Farmers Without Forest Permits:	<u>500</u>	<u>200</u>
Total Stock Population	44,859	1,199

The 45 largest outfits, those owning over 100 head each, together own 43,376 cattle and 910 horses, or 97% of the cattle and 76% of the horses. These outfits together have

13,623 cow units out of a total of 14,512 in the National Forest within the drainage area, or 93.7% of the permitted stock.

According to the local rangers, all the stockmen in the area with commensurate range who wished to get Forest permits were care for. Of the 68 permittees, 27 have permits for all of their cattle, including 14 of the large operators.

The number of acres per cow unit yearlong in the entire county is 15. The number of acres per cow unit on the private lands is 7, and, as has been indicated, the number of acres per cow unit in the National Forest is 33.

Livestock in Pima County

There are no data comparable to those available in Santa Cruz County for Pima County. The U. S. Census for 1930 gives the total number of cattle in Pima County as 89,821 in 1929. The Pima County agent estimates a cattle population in 1937 of between 70,000 and 75,000 head. The horse population is given by the census in 1939 as 7,309 head, and the county agent estimate for 1937 is approximately 8,000 head. There are practically no sheep in the county.

There is undoubtedly a concentration of this livestock, particularly of the horses, in the SantaCruz drainage area, but the extent of this concentration is impossible to estimate. An exact geographic distribution of cattle would give 15200 as the

number of cattle in the drainage area of the Rillito and the Santa Cruz above Tucson. This would indicate that an area two times the size of the drainage area in Santa Cruz County supports only one-third as many cattle. According to technicians in the area who are well acquainted with the ranges, this is probably a good estimate of the ratio the carrying capacity of the ranges in the two areas. This indicates that the stocking of Pima County range is 90 acres per cow unit.

Use of the Mexican Portion of the Santa Cruz Watershed

The Green-Canales Corporation, which owns some 46,000 acres of land in the Arizona portion of the Santa Cruz drainage area, owns all of the eastern half of the Santa Cruz Watershed in Mexico. This is a fabulous outfit whose livestock holdings are reported variously at from 600,000 to 1,000,000 head. Entire villages are in their employ, and they carry on tremendous mining and farming operations besides their livestock enterprise. It was reported that they control a strip nearly 50 miles wide and extending 150 miles from the Arizona border into Sonora, and that these lands are conservatively grazed so that they are in excellent condition. This report was not verified.

The other half of the Mexican portion of the watershed belongs to two Mexican outfits, except for the drainage area of the Nogales Wash on which is located the city of Nogales, Sonora. The lands belonging to the two cattle outfits, each of which has a breeding herd of 5,000 cattle, are reliably reported to be in good condition. The entire Nogales Wash is now a flood control area under the Mexican Department of Forestry, Fishing and Hunting. This area has been intensively worked. After establishing complete grazing exclusion by presidential decree on the project area, 4,000 check dams were built, and an elaborate tree-planting and grass reseeding program was initiated. This program has been so successful that for the first time in years, no destructive floods descended on Nogales. Interesting problems with regard to the establishment of stock exclusion on the project area, and the finding of substitute range for the domestic stock of the residents of Nogales had to be met by the staff in charge of the Nogales project. The solutions that they worked out appear to warrant some study by Soil Conservation Service because of similarity to the problems encountered in many areas of Region 8.

Summary

Only that portion of the Santa Cruz Watershed above the confluence of the Rillito and the Santa Cruz is discussed at

all fully.

The area of that portion of the watershed under discussion is approximately 3,000 square miles, and in it are included the most important lands insofar as human dependency is concerned. Seventy-five percent of this area is under Federal ownership or control.

There are two important population centers, one of which, Tucson, completely dominates the entire area.

Agriculture differs markedly from the lower to the higher reaches of the drainage area. In the lower altitudes, mostly located in Pima County, the chief crop is cotton. In the higher altitudes, located in Santa Cruz County, the chief crops are supplementary feed crops. In the former, cattle raising and cattle feeding are secondary to cotton raising; in the latter, cattle raising is the chief industry. The carrying capacity of the ranges in Santa Cruz County is approximately 6 times higher than in Pima County. Even so, there appears to be an excessive amount of stock on the Santa Cruz County range, especially upon the private lands.

There are approximately 1,100 farm and ranch operators in Pima and Santa Cruz Counties practically all of these are in the Santa Cruz watershed. Farming and stock raising are the most important sources of livelihood in the area although

mining approaches them in importance. The relative dependence upon mining and agriculture in the area has not been determined.

No attempt has been made to discuss floods and flood damage in the absence of precise data. Although the Santa Cruz County ranchers pride themselves on the ruggedness of their individualism, they depend for at least 30% of their grazing on Federal lands, and the Federal government, therefore, has an effective control over the drainage area, particularly in its upper reaches away from the stream beds.

